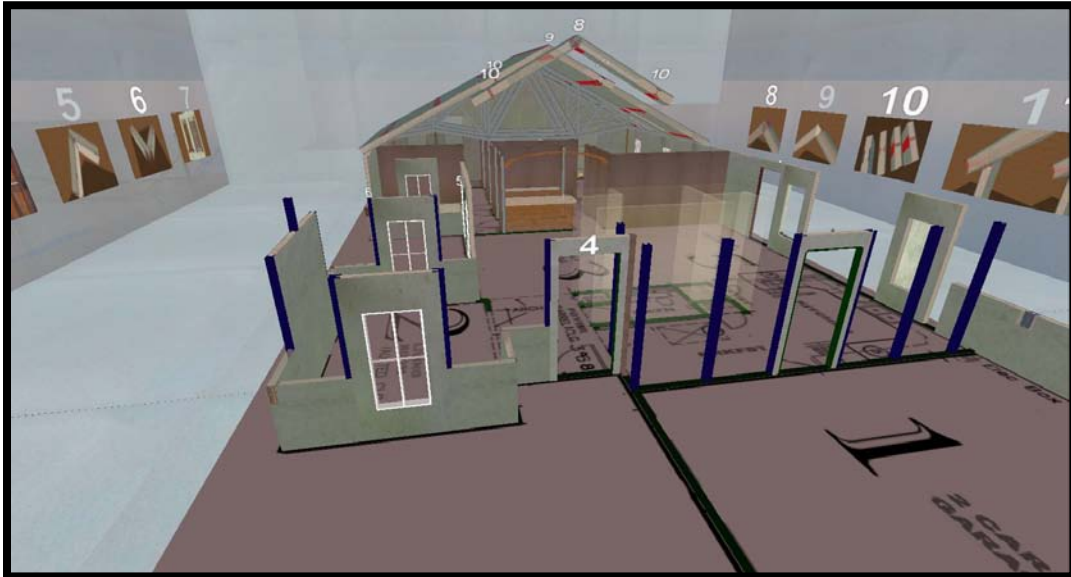# Building Inspector Virtual Training Pilot

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This report has been prepared for Lawrence Berkeley National Lab and the Department of Energy as the deliverable for Task One of the FY2009 FAS Scope of Work, which tasked FAS with creating an online tool to improve understanding amongst building inspectors on code compliance and constructability issues for advanced building systems and to give inspectors a baseline understanding of building energy performance concepts.

This report summarizes existing training methods and tools for building inspectors and code officials, concluding that they are inadequate to meet today's pressing need for housing that is more energy efficient and sustainable. Virtual tools are a promising solution to these training inadequacies due to many factors, including their interactive nature and capacity for remote collaboration and learning. In order to assess this virtual training concept, FAS has created a pilot program to train building inspectors on energy efficiency and thermal tightness concepts and on how to inspect a residential building constructed with Structural Insulated Panels (SIPs). The results of this pilot, including lessons learned and recommendations for future virtual training development are included in this report.

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Introduction and Explanation of Training Gap

With the building sector using more energy and more electricity than any other sector in the United States,[1] this sector must become vastly more energy efficient and sustainable if the nation is to reach its carbon reduction goals. In 2008, the residential building sector alone was responsible for almost 22% of the nation's total energy consumption.[2] Through both retrofits of existing houses and through building more efficient new houses, there is great opportunity and potential for energy savings within the building sector. However, achieving these energy savings will require utilizing advanced technologies, materials, and systems that increase building envelope tightness, waste less energy, and improve building comfort and security for occupants.

One of the key barriers to the wide-scale adoption of energy efficient, high performing materials, practices, and technologies is a lack of education and training. Professionals and tradesmen often do not know to design with, install, or inspect these advanced materials and technologies, which therefore are infrequently used and when utilized, do not perform optimally due to installation errors. In order to facilitate their adoption and take advantage of the capabilities of these advanced products, training must be improved throughout the industry; without this improved training they will neither achieve significant market penetration nor achieve their energy efficiency potential.

The Federation of American Scientists has worked closely with manufacturers of and industry professionals who work with structural insulated panels (SIPs), a high performing and energy efficient building system. SIPs can be used for walls, flooring, and roofing and serve as an insulator, structural support, and weatherproof barrier; they are structurally strong, have high thermal resistance when properly installed, produce little waste as they are manufactured and cut in the manufacturing plant, and are installed quickly and with fewer labor hours than a traditional stick framed structure. Despite possessing these many positive attributes, market uptake of SIPs has been minimal. Manufacturers and representatives of the Structural Insulated Panel Association (SIPA) note that building inspectors and code officials are frequently neither familiar with SIPs inclusion in the International Residential Code (IRC)[3] nor inspecting SIPs for proper installation. In order for SIPs to be widely adopted by the building industry and in order to ensure that code compliant and efficient installation occurs, improved SIP training tools for building inspectors are needed.

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[1] Architecture 2030 estimates that in 2000 the building sector (including residential, commercial, and manufacturing buildings) was estimated to account for 48% of the nation's energy consumption and 76% of the electricity consumption.
Architecture 2030, "The Building Sector: A Hidden Culprit,"
http://architecture2030.org/current_situation/building_sector.html (accessed September 28, 2009).

[2] Energy Information Administration, "Table 2.1a: Energy Consumption by Sector, 1949-2008," *Annual Energy Review 2008*, http://www.eia.doe.gov/emeu/aer/contents.html (accessed September 28, 2009).

[3] SIPS are included in the 2009 *International Residential Code*, Section R613.
International Code Council, *2009 International Residential Code For One- And Two- Family Dwellings*, (USA: International Code Council, Inc., 2009), 348-356.

Current Industry Training Methods

The International Code Council (ICC), American Society for Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), American Society of Home Inspectors (ASHI), National Association of Home Inspectors (NAHI), Institute for Building Technology and Safety (IBTS), and private and state/municipal training organizations all offer building inspector courses to train potential and current inspectors on understanding and inspecting for code compliant building practices. And while numerous organizations offer training programs, certification to become a certified building official (CBO) can only be given by either the municipal/state government or one of the major CBO organizations, such as the ICC or ASHRAE. These two organizations, in addition to certifying CBOs and holding certification exams, also offer courses that train building officials either to pass the exam or for the purpose of continuing education. Most of courses and seminars offered take place primarily in the classroom and emphasize a format of instructor lectures and student memorization of key codes and code concepts. In the classroom instructors use tools such as code books, written materials, and media such as videos and CDs to aid students in learning content.

In addition to classroom time, many courses include time in the field (usually no more than one day) learning how to do an inspection from an experienced instructor. Courses taken in order to prepare for a certification exam, such as the ICC's Residential Building Inspector certificate exam, almost always include both the classroom and field elements as students must both pass a written examination and a field examination, thereby proving both their knowledge of codes and related concepts and their ability to actually perform an inspection.   In recent years both the ICC and ASHRAE have begun to offer online training courses as an alternative to the physical classroom; these courses are referred to by the ICC as eTraining or as ICC Online Campus courses and by ASHRAE as eLearning courses.[4]

These instructor-led online courses or "webinars" cover nearly identical content to and follow a nearly identical format to the non-web courses, with an instructor lecturing and teaching to students via video streaming and the students interacting with their instructor and asking questions in the online training environment. In addition, students can take independent online training courses; these courses consist of reading a section of the code or an explanation of an important concept, then answering problem solving-style questions that utilize graphs, charts, and other media related to code concepts. Full-length web-based practice exams are also offered to assist in reviewing course material. Collectively, the existing web education capabilities consist of virtual lectures and seminars; making written materials available, including code sections and summaries; online practice exams; and online independent courses that educate students about codes and code concepts through limited interactivity, written material, and media (i.e. videos, photos, and interactive charts and graphs).

However, very little of the virtual content actually prepares students to be building inspectors. They are not shown how to do a walk through; they are not able to practice comparing actual construction to structural and architectural plans; they cannot simulate interacting with the parties involved in an inspection; and the interactive features are in reality little more than a picture or graph that, when clicked, pops up a one sentence explanation of the content. And while webinars allow the instructor and students to verbally communicate and the students can see the instructor via video feed, the instructor cannot simulate an inspection or show the details or plans being discussed, and the opportunity for social interaction is highly limited. Moreover, the training structure is almost entirely

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[4] International Code Council, "ICC Campus Online," http://www.icccampus.org/ (accessed September 28, 2009). American Society of Heating, Refrigerating and Air-Conditioning Engineers, "ASHRAE eLearning," http://www.ashrae-elearning.org/ (accessed September 28, 2009).

based on verbal and written memorization and regurgitation, with little opportunity for kinesthetic learning and little thought given to improving the understanding and application of knowledge by encouraging transfer[i].

To develop a workforce of inspectors who understand both the need for energy efficient advanced technologies and how the code applies to energy efficient technologies and materials, training needs to be more interactive, provide opportunities for kinesthetic learning, promote transfer, transcend geographical limitations, and be structured as an integrated program that weaves together written curriculum content and field exercises and training.

Virtual Worlds and Web 2.0

The tools of web 2.0 and the latest iterations of virtual worlds possess the capabilities to carry out advanced, remote, and highly interactive simulations, trainings courses, and educational seminars and demonstrations needed by the building industry.

Current State of Virtual World Industry and Development

Estimates by Gartner, an information technology research consultancy, project that by 2011 80% of active internet users will have a virtual world avatar in some virtual world. This represents a significant market penetration rate and signifies that by utilizing virtual worlds, trainers and educators will not be introducing students to an unknown technology, but rather introducing new content through a known and understood medium.[5] This medium has been used by both the corporate and education worlds to hold meetings, conferences, and classes, to collectively work on projects and bring together experts from different places, and to network and socialize. At Harvard University, for example, students can earn credit for a course attended in a virtual classroom. And at Intel, conferences and meetings are often held at the virtual Second Life conference room. Research by the Palo Alto Research Center indicates that group interactions and teamwork, psychological responses, and learning within the Second Life world closely mirror that in the real world; as such, training and simulation modules that are designed to be interactive, hands-on, and mimic real-life scenarios can yield mental retention and learning similar or even equivalent to that of the real-life scenario.

To assess this theory and the value of virtual worlds in training adults to master complex skills, content, and scenarios, medical schools and health care facilities have begun to utilize virtual worlds as state-of-the-art, interactive, and highly realistic training environments.

The Imperial College London, for example, has built a virtual hospital in Second Life. The hospital includes a virtual operating room, where students practice treating patients and dealing with common emergencies and operations, and a Virtual Respiratory Ward, where students test their knowledge of respiratory problems by interviewing, diagnosing, and recommending treatment for patients. While the medical field has used simulations for years via dummy operating and treatment rooms and software-based SIMs, early adopters note that the primary advantages of virtual world clinical training are: the ability to bring geographically distant people together for the simulation, the low cost, and the ability to simulate otherwise impossible or unsafe situations. In using a virtual world, training programs can bring experts from around the world into one clinic to teach students and lead post-op discussions, while

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[5] Garnter Inc., "Gartner Says 80 Percent of Active Internet Users Will Have A "Second Life" in the Virtual World by the End of 2011," http://www.gartner.com/it/page.jsp?id=503861 (accessed 28 September 2009).

allowing students to network and discuss their work, all at a much lower cost than bringing all parties into the same physical clinic. Scott Diener of the University of Auckland notes that "We tested [the virtual O.R.] in a controlled experiment on 40 first-year medical students prior to their first visit to a real O.R. We wanted to determine if [the SL program] gives them more confidence before their first exposure to the real thing. We've found it is just as effective as the training O.R. in the physical world."[6]

Diener also emphasizes that virtual world simulations can expose students to situations that a standard academic program cannot duplicate: "[SL] is not about creating an automated teaching environment. It's about giving students experiences we can't give them otherwise, because it's impossible or unsafe." [7] Thus, while there is not a great deal of empirical evidence as to the effectiveness of Second Life as a training platform, initial studies by medical schools indicate that there are advantages to using virtual worlds over both classroom instruction and physical simulation in terms of the convergence of low cost, access to experts, and scenario-based simulation.[8]

The virtual world environment is currently the only means by which to bring people together in an interactive environment without necessitating any physical travel.   This capability, one of the most important, reduces training expenses as building a virtual world simulation and putting participants in that scene costs a fraction of what it costs to build a real world simulation and transport participants to the site. Within the immersive environment participants can network, socially interact both verbally and face to face (or rather avatar to avatar) and can work together to solve problems or simulate real-life scenarios, just as they would be able to in the real world.[9]

In terms of the building industry, potential simulations could include participants building or designing housing components or entire houses as a team, being shown new technologies and techniques by industry experts, reviewing or assessing a built structure, or inspecting the structural problems that led to the destruction of a virtual building in a post-disaster simulation scenario. And as people intellectually and emotionally react similarly in both the physical and virtual worlds, the virtual world can be effectively used to familiarize students with concepts, places, and situations they will encounter in the field, but have never previously experienced. As a result, in the physical world the learning curve is shortened and problems encountered can be dealt with not as new experiences, but as previously encountered and solved problems.

Second Life
Second Life specifically is a useful training environment as it is currently the largest and most comprehensive virtual world. From building objects and avatar interactions to modeling energy or water flows, leakage, and thermal resistance, Second Life is at this point the world wherein the most advanced and realistic whole building modeling and simulation can be done. In addition, under the training model currently employed by ASHRAE and the ICC participants pay to take both courses and to take the certification exams; with Second Life Grid platform and Second Life Work (the version of

[6] Melissa Lafsky, "Can Training in Second Life Teach Doctors to Save Real Lives?" *Discover Magazine* (2009), http://discovermagazine.com/2009/jul-aug/15-can-medical-students-learn-to-save-real-lives-in-second-life (accessed September 28, 2009).
[7] Ibid.
[8] Citation from Sachin on scenario-based learning
[9] Greg Wadley and Nicolas Ducheneaut, "The 'out-of-avatar experience': object-focused collaboration in Second Life," (paper presented at the European Conference on Computer-Supported Cooperative Work, Vienna, Austria, September 7-11, 2009), http://disweb.dis.unimelb.edu.au/staff//gwadley/roc/ECSCW09-WadleyDucheneaut.pdf (accessed September 28, 2009).

Second Life targeted toward corporate, government, and education users) training organizations need not alter their revenue model as the professional edition allows owner to keep their property and content behind a password protected firewall. Though the behind-the-firewall option is currently in beta form, it will allow property owners to limit access to all or part their properties, thereby allowing a training space to be accessible only to registered users for a specific period of time. For example, in signing up and paying for a building inspector course trainees would be paying for access to a particular training environment for a set period of time (such as 90 days) in order to participate in the formal training course, then continue to use that same environment to practice and enhance the skills and knowledge learned from the instructor.

Virtual World Adoption Barriers
There are key issues that at the present time inhibit the large-scale adoption of virtual worlds as a tool for business and education. The primary problem is the lack of interoperability and compatibility between virtual worlds. An object built in Second Life, for example, cannot be exported into another world and vice versa; with different coding languages and data formats, despite the open source nature of coding languages (referred to as Linden Scripting Language in Second Life), content and language can only be shared within that limited world. Industry analysts therefore recommend against making huge monetary investments in virtual worlds until such a point that the various platforms are compatible. However, while large-scale investment in one platform for commercial purposes is unwise until such a point that virtual worlds are compatible or integrated, this logic does not as readily apply to education. For the purposes of education and training, the cost savings of training in a virtual world environment is immediate and ongoing and the objective is to use the environment as a tool for educating and training an audience acquired through non-virtual means rather than to meet the commercial objective of promoting a product or brand image to potential customers encountered within the virtual world.

A second barrier to virtual world business and education adoption lies in that each user must have Internet access, computer access, and basic familiarity with operating within the virtual world as well as its functions and capabilities. Without reliable Internet and computer access, participants cannot take advantage of any virtual world training and without a basic virtual world familiarity, participants must undergo an additional orientation and adjustment period while learning how to operate and function in a virtual world. The necessity of learning these new virtual world skills in addition to the course content may deter some potential participants from utilizing this new training platform. However, according to the 2009 Digital Future Report by the Center for the Digital Future, over 80% of people in the United States now use the Internet and only 15% of homes do not have a computer. Of the Internet users, over 80% connect have a Broadband Internet connection.[10] Thus, lack of reliable Internet and a computer is becoming increasingly less of a barrier. When these figures are coupled with the estimate by the Gartner Group that 80% of Internet users will have a presence in non-gaming virtual worlds by 2011, it is apparent that the majority of the working age American population has familiarity with the Internet and at least a basic familiarity with virtual worlds that will rapidly grow over the coming years.[11]

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[10] Center for the Digital Future, "Digital Future Project Release Highlights," 2009, http://www.digitalcenter.org/pdf/2009_Digital_Future_Project_Release_Highlights.pdf (accessed September 28, 2009).
[11] Anders Gronstedt, "Virtual World Learning," *Training Magazine* (2007), http://www.salesandmarketing.com/msg/content_display/training/e3icb706624eaa6b047f367f6c5ec543baa (accessed September 28, 2009).
Anders Gronstedt, "Training in Virtual Worlds," *Training Technology and E-Learning*, Iss. 0803 (2008).

At present, there is no simple mechanism by which to connect virtual worlds to outside resources and data. Objects can be linked to outside web sites, but creating a library of information, supporting resources, media, learning activities, and assessments, then gathering all of that content into one organized, easy to understand location is not possible in the virtual world. This ability to organize and link materials and content to the virtual world is a necessary feature for most trainers and educators as the simulation in the virtual world is not a stand alone, but a key component of a larger curriculum. In the case of training building inspectors, the virtual scenarios and instructor-led sessions are a component of a course that needs numerous components to be effective, including materials such as exam preparation documents, practice exams, and code books, and tools such as media, discussion forums, architectural CAD images and structural and engineering drawings.

As such, in order for virtual worlds to become an effective and widely used learning environment, they must be integrated with a simple, user-friendly platform with features including, but not limited to: materials storage and organization, curriculum and content explanations, wiki and forum integration, and assessments and assessment results storage. Through integration of such a platform with virtual world training environments a truly interactive, immersive, innovative education and training tool can be created.

Medulla

In order to solve the issue of the inability to easily integrate virtual worlds with outside resources and data, the FAS has created Medulla, an independent platform that weaves together virtual worlds and web tools. The purpose of Medulla is to allow:

   a. collaboration among users across virtual worlds, Medulla tools, and third-party tools including commercial web applications;
   b. interoperation between two independently hosted web applications irrespective of their internal composition; and
   c. creation and archiving of content in virtual worlds that is viewable and searchable on the web (for further details on the functionality and purpose of Medulla, see Appendix 1).

Specifically, Medulla weaves together tools such as digital archives (DSpace), wikis, virtual worlds, and digital media such as videos and photos and organizes them in an open source, easy to navigate template. This template allows the project manager to tailor the template for the target audience, writing descriptions and learning objectives for the training module as a whole as well as individual scenes and objects within the immersive training environment; link each template (including its written content and supporting materials) to a virtual world or multiple virtual world scenes; create and post learning activities and scenario guides; and organize references, media, learning activities, and supporting materials into categorized group boxes. In addition, all registered users can upload files to the group boxes and edit the project's wikis, allowing users to learn form and contribute to an interactive and constantly evolving project that works with and within the virtual world and gathers the curriculum and learning content into one simple template.

The Building Inspector SIP Training Module Pilot

Utilizing the Second Life virtual world and the Medulla web platform, FAS has created a pilot project to test the feasibility of training building inspectors in the virtual world. The specific goals of this project are to ease the adoption of advanced building technologies and to improve training related to energy efficient construction and advanced technology in the construction industry. The pilot also seeks to improve understanding of code compliance and constructability issues among building inspectors and

code officials. More broadly, this pilot seeks to teach residential building inspectors how to properly inspect a home built with SIPs by educating and then assessing the trainee on code compliance issues with SIPs, common installation errors, and energy efficiency concepts. A highly flexible training tool, the virtual world environment can be used in formal instruction, to independently learn practice inspecting, to expand conceptual knowledge of energy efficiency and SIP concepts, and for self-assessment. As such, virtual world space has been designed with the goal of providing an intuitive and interactive learning environment that is highly flexible and connected to relevant, engaging, and educational materials and media.

Summary of Training Module Functions and Components

In this module, the SIP training and assessment primarily occurs within the Second Life virtual world, with additional content, supporting material, and training tools hosted on Medulla. Key topics covered by Medulla content include: the purpose and goals of the training module; background on how Medulla and Second Life work and interact; how to function within the Second Life world; the capabilities of the training environment and virtual world; scenarios for independent and instructor led education; skills that the trainee will acquire; information on SIPs and constructing and inspecting SIP houses; and detailed data about key components of SIP architecture and engineering. This information is provided to users by through a variety of mediums, including text, images, architectural and structural drawings, video, and models of real and virtual SIP structures.

The Building Inspector SIP training area is broken into three primary components: the Introduction and Orientation area, the Training House area, and the Assessment House area. The objective of the Introduction scene is to familiarize users with Second Life, provide information on SIPs and introduce users to SIP fabrication, materials, and installation, and provide a brief overview of key concepts in energy efficiency.
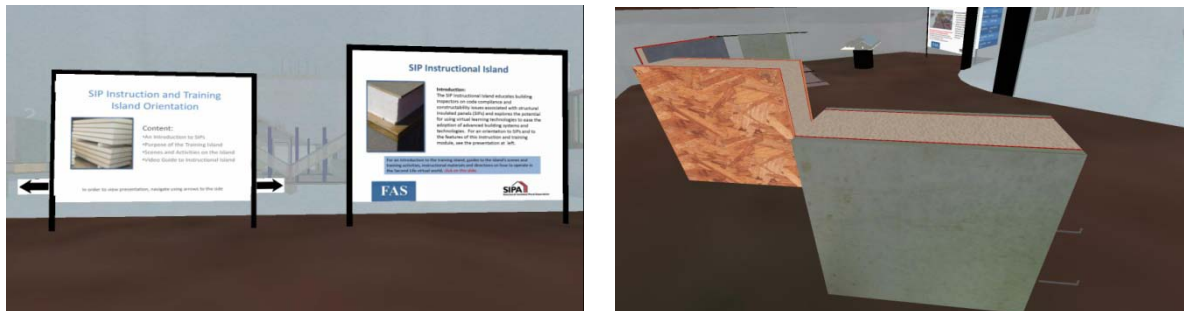

Figure 1. Introduction and Orientation Scene: billboard, presentation, and SIP models

Users begin their exploration of the virtual environment in the Introduction and Orientation area by linking to the necessary "how to use this module" documents on Medulla (included as Appendix 2) and watching a presentation on SIPs and energy efficiency. After watching the presentation users explore the Introduction and Orientation area with the aid of the "Scene 1 Activities Guide," (see Appendix 3) which includes animated models of SIPs and SIP construction techniques, learning materials, and information about SIP fabrication and installation. Once the user has thoroughly investigated this introductory scene, the user moves onto that main instruction scene, the Training House.

In the Training House scene users encounter a SIP demo house modeled off of the architectural drawings of a real SIP house. This house represents multiple stages of construction from laying the foundation to installing exterior cladding. At each stage the demo house demonstrates proper installation techniques and materials use, emphasizing safe construction and tightness of the building

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envelope. Throughout the house nineteen construction details are marked with white numbers; each of these is a detail commonly installed improperly or around which there is frequent confusion regarding proper installation and sealing/insulating. In order to find out more about that particular detail the user simply clicks on the white number above the detail and is taken to the Medulla site, which houses a description of the detail and common installation mistakes, CAD images of the detail, and screenshots[ii]
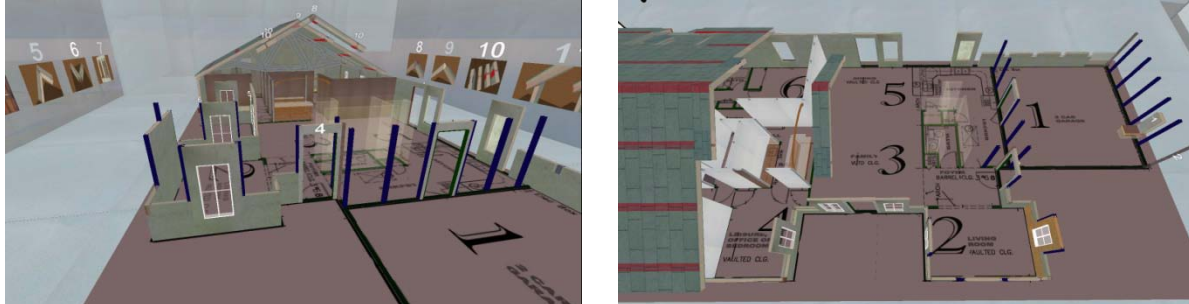

showing the detail. As a complement to the Training House, the adjacent Gallery indexes screenshots of each detail, allowing the user to visually review the details in the house. And as with the Training House, in order to obtain more information about or CAD images of a detail the user clicks on the number and is directed to the appropriate Medulla page.

Figure 2. Training House Scene: Training House and Gallery

Users spend the majority of their time in the Training Demo House as this scene is where the majority of instruction, independent investigation, and learning take place. Either with the aid of the written "Scene 2 Learning Activities Guide" (included as Appendix 4) or with a building inspection instructor, trainees are led through a simulated inspection of the Training House's structural elements, SIP connections, roofing connections, electrical, and plumbing. While the "Guide" and supporting materials contain a great deal of information, to take full advantage of virtual world capabilities such as asking questions and receiving immediate feedback, socializing or networking with colleagues and the instructor, and collectively troubleshooting problems, a formal, instructor-led walk-through is necessary. Once the mock inspection has been completed, trainees can independently practice inspecting a house on their own, and explore SIP construction and energy efficiency both in Second Life and through the reference materials in Medulla. In addition, if students have questions about a particular component encountered in the Training area or wish to discuss building, training, or inspection-related issues with their colleagues or an instructor, this scene is linked to an open wiki.

In the final Second Life scene, the Assessment House scene, users test their knowledge of SIP construction techniques and concepts. The specific objective of this scene is to allow students to apply the information, process, and principle-based knowledge gained through the mock inspection and investigations of the Training House. To this end, the scene contains a house nearly identical to the training house except in that of the nineteen details from the Training House ten have been constructed improperly, compromising either the structural integrity or tightness of the building envelope. Each mistake was deliberately made to mimic a mistake commonly made by SIP installers in the field. A self-assessment mechanism, this scene contains both knowledge-based and principle-based multiple choice questions that the student answers and received immediate feedback on. Where the student does not answer a question correctly, that student is encouraged to visit the corresponding informational materials on Medulla to improve their understanding of that particular concept or proper construction component.
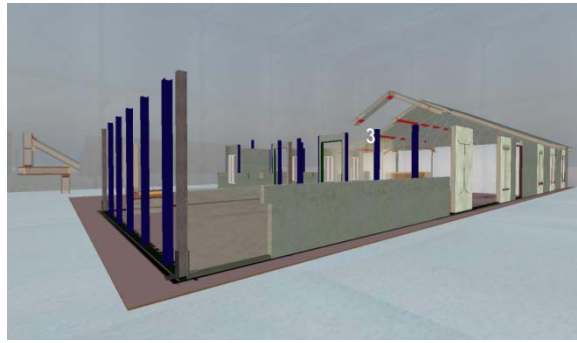
Figure 3. Assessment House Scene

One informational question, for example, asks:
"Correctly identify the mistake in this detail. A) There are no mistakes. B) There is no flashing. C) The panels are not correctly screwed together. D) The cladding is not ventilated."
And further into the house users are presented with the conceptual question: "The electrician has cut channels for wires in the field. Did the electrician wire the house correctly? A) Yes. This is the correct procedure. B) Yes. It is not standard procedure according to the manufacturer's directions, but is a widely accepted method of wiring a SIP house. C) No. Cutting into the SIP exposes toxic insulation. D) No. Cutting into the SIP compromises its R-value."[12]

A highly adaptable scene, the assessment house and questions have been designed to be easily and quickly modifiable, allowing the house to serve an ongoing educational purpose. By changing the details to illustrate different mistakes and creating new conceptual questions, new assessments can be continually developed to further address the continuing education requirements and desires of current building inspectors.

Advantages of this Virtual World and Web Training Pilot

Though dissemination of this pilot has been minimal, industry experts have explored and offered feedback on the training module's virtual world content and the Medulla-based training guides and reference materials. Initial feedback of this pilot has validated many of FAS assumptions regarding the advantages of virtual world web training over classroom or current webinar courses. As determined by feedback, the primary advantages are: the capability to show 3-D, highly detailed, architectural and structural details; the connectivity between the virtual world components and related information, data, and CAD images; the ability to demonstrate code compliance features and issues in a relatively inexpensive and time efficient manner; and the ability to collaborate, instruct, and train remotely.

In order to assess the remote instruction and education potential of this pilot we gave basic instructions to industry professionals, asking them to use our Second Life Orientation guide to create a Second Life account, login to the Medulla platform and Second Life, and explore the Training Module independently. We then went through the training module with the same group, discussing features, critiquing the details in the training house, and discussing potential operability additions to the virtual world. While users had minor to substantial trouble acquiring a Second Life account and creating an avatar and recommended we devise a simpler method of accessing the virtual world environment, once logged in the users found the environment to be highly useful for independent study of codes and energy efficient building materials and concepts. The building details and animations especially were found to aid the user in understanding proper construction techniques, while the interactive links to Medulla were found to be highly useful in learning conceptual material.

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[12] Federation of American Scientists, "Building Inspector SIP Training Pilot," in Second Life virtual world, 2009, http://slurl.com/secondlife/FAS/147/49/27 (accessed September 28, 2009).

Our subsequent group walk-though convinced users of the advantage of this virtual world for formal instruction, allowing instructors to present specific scenarios and demonstrate the process of inspecting, while simultaneously allowing trainees to interact with one another and the environment. Moreover, both instruction and independent exploration can be both highly tailored to the needs of the target audience and experts can be brought in to teach courses regardless of the geographical location of the expert or the students. While initial feedback indicates that minor changes and additions to both content and interface must be made prior to the Training Module's adoption on a large scale (feedback is further discussed below), this method of training possesses significant advantages over existing training methods.

Lessons Learned from Creating Building Inspector Training Module

Through creating this pilot training module and introducing building professionals to the module, FAS has learned key lessons relating to the process of training module development as well as how to improve and update the course and virtual world.

Building in the Virtual World
In a virtual environment where the detailing and scale is essential, such as in the Training House, building within the virtual world can be an arduous process. For complex and detailed models and building components, building in the virtual world is not always ideally precise and textures cannot be tested on an object before they are imported. Instead, creating components in an architectural CAD or 3D sculpture modeling program and then importing them into the virtual world yields more precise components that better match the specified architectural and structural plans. In addition, it is necessary to partner with suppliers and manufacturers of raw building materials in order to obtain properly detailed images and textures for architectural models. These manufacturers are also an excellent resource from which to obtain the detailed specification drawings necessary to make 3D models as well as the engineering data on various materials and joints or connections.

New User Orientation
Developing virtual building inspector training on a large scale will require easing the adoption of this new training tool for those without high computer literacy. Currently, the Training Module has a written introduction on how to use the virtual world, create an avatar, etc. However, this virtual world orientation process must be made simpler for the inexperienced user. One possible method of simplifying orientation would be to use video, a familiar and widely-known medium, to show new users how to sign up and create an avatar or operate an existing avatar. A second method would be to create premade training avatars that, when coupled with an auto-logon feature, would altogether eliminate the need to create an avatar and log into the virtual world.

Virtual World Content
Expansion of content and stronger integration with web tools is essential to building a successful virtually-based training module. As the primary training mechanism, the virtual world must have multiple environments that can be utilized either individually or collectively to meet different training objectives for different audiences. In order to make the most useful training environments possible, it is necessary to register all models as open source and to take advantage of the object copying capabilities of the virtual world; with these two capabilities all houses in the module can be built from the same

base model and then altered to meet the specific requirements of professional audience and local code (i.e. structural engineers and inspectors in California). Using the same base environment, with highly similar conditions, drastically reduces the programming costs of module expansion and enhances the ability of users to gain and retain new knowledge.[iii]

Within this immersive environment, each object and each scene must be highly interactive, requiring the user to manipulate the environment in order to gain additional knowledge. Within the current training module each building component of the Training House is moderately interactive in that to learn about that detail you must click on it; in addition, the Orientation area contains some avatar-controlled animation and models. However, navigating the Training House does not at present require the user to manipulate any objects within the scene and research shows that requiring avatar manipulation or enabling the "what if?" element of cause-effect interactions improves knowledge transfer and retention.[13]

In addition, there is currently limited capacity for kinesthetic-based problem solving (i.e. the user virtually building or altering some component of the house) and this kinesthetic oriented content is needed in order to bring together the classroom learning with the hands on field learning. To meet this goal of weaving together written content and field practice, future building inspector virtual training modules must have multiple learning scenarios and simulations for each scene and each audience. These scenarios and simulations should be engaging, have focused objectives, and be limited to a small area of the environment (1-2 scenes) in order to not overwhelm the user and to focus attention on learning material not exploring. Well-designed scenarios can model real life experiences and situations, resulting in better prepared and more capable inspectors and building professionals.[14]

And finally, the virtual world content must be strongly linked with a curriculum and toolset that is housed outside of the virtual world in an independent web platform. Basing tools and curriculum content in the virtual world requires relying upon the virtual world developers to update technical capabilities and fix interoperability barriers, which is not an ideal solution due to the limitations previously discussed. Rather, hosting course materials and toolsets on an adaptable, user-friendly template in an outside web platform overcomes the limitations of the virtual world and allows for greater control over the tools, course and material organization, and degree of immersion in the virtual world.

Recommendations and Next Steps for Virtual Training

FAS recommends that the next step toward meeting the goal of improving training for building inspectors and code officials be the creation of a comprehensive training module and correlating small-scale training program. This comprehensive module must include both an immersive virtual world training environment and web-based toolkit and must incorporate the lessons learned from this initial pilot.

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[13] M. Suzanne Donovan, John D. Bransford, and James W. Pellegrino, eds., *How People Learn: Brain, Mind, Experience, and School: Expanded Edition* (Washington, D.C.: National Academies Press, 2000), http://www.nap.edu/catalog.php?record_id=9853 (accessed September 28, 2009) 51-78.

[14] Ruth Clark, "Accelerating Expertise with Scenario-Based Learning," *Training + Development (T+D)* (2009), http://www.clarktraining.com/content/articles/ScenarioBasedLearning.pdf (accessed September 29, 2009).

In order to create a high quality training module, the curriculum development and architectural modeling must be done in partnership with industry experts, including structural engineers, architects, and materials representatives or manufacturers, code officials/building inspectors, and private code organizations such as the ICC and ASHRAE. This will allow the virtual environment, simulations, and scenarios to represent the physical world as closely as possible and will enable the virtual environment and toolkit to integrate energy efficiency concepts via energy flows modeling.

Within the virtual environment, the prototype virtual house must be built to the specific code of one state or municipality, allowing the house to be used as a realistic training tool for the building inspectors and code officials in that area. This house should have expanded functionality over the pilot Training Demo House, including the capability to model energy flows within the house, greater interactivity that includes the ability to manipulate the house's materials and construction, and the addition of problem solving activities and scenarios.

FAS recommends that the next iteration of the training module focus primarily on developing the platform of tools outside the virtual world environment. At present, the state of virtual world technology is such that it cannot be easily integrated with web-based tools and virtual worlds lack interoperability with one another. In order to compensate for these technological gaps and enable large-scale adoption of immersive web training, an independent platform is needed to house tools, materials, and other training content. This platform must have a template that is intuitive and straight forward, with the capacity to be flexible and expandable as training courses and tools are added.

In addition, there must be greater integration of the virtual world with web-based tools and content; to this end the virtual world should not be seen as the primary training platform, but as a tool for immersive learning, scenarios, problem solving, and processual learning within the larger, independent training module. Focusing on building and expanding the learning module's content and courses will allow multiple activities for multiple audiences to utilize the same virtual world scene. This capability will, most importantly, save money due to reduced virtual world development costs. In addition, the environments for related courses will appear nearly or completely identical, shortening the user's learning curve as the environment need not be re-learned and re-explored for every new course or simulation. If a building inspector were to take a course of formal instruction, for example, the environment in which the course takes place would look almost identical to those in which the inspector practices inspecting via virtual scenarios and independently studies the course's concepts. The scenarios, formal course, and independent exploration would all utilize different tools and templates within the independent platform, but the same virtual world environment.

A final recommendation for future virtual training development relates to deployment strategy. In order to assess the feasibility of large-scale virtual world training for inspectors, a small-scale training pilot must be carried out to train approximately 100 students in how to inspect an energy efficient, code compliant house that uses advanced materials and building systems, such as SIPs. Recruiting participants and gaining buy-in for the technology requires utilizing existing partnerships with current code certification organizations, construction-related certification programs at schools and institutes, local or municipal-level building code offices, and adult education programs. With input from these partners, the learning module, the virtual world environment, and the web-based tools can be assessed and improved. And assuming the pilot virtual training course demonstrates greater success than a traditional course, a full-scale deployment strategy can be developed to create a virtual training program that trains, assesses, and certifies existing code officials to inspect residential buildings that have energy efficient features and advanced technologies.

Conclusion

In order to meet our nation's energy efficiency goals thousands of construction professionals will need to be trained in how to design with, build with, retrofit, and inspect energy efficient and technologically advanced buildings. Doing so requires that training move beyond classroom based and simple web-based methods and tools currently utilized. Training must utilize advanced web tools and immersive virtual world training in order to teach building professionals content, process, and concepts in an efficient, dynamic, and inexpensive manner. To this end FAS recommends the development of web-based learning modules and corresponding pilot training programs in order to assess the utility of virtual world training and to begin the process of training workers for a greener, more energy efficient, building industry.

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Appendixes

Appendix 1: About Medulla

Appendix 2: Learning Activity 1 "Second Life Orientation and Practice Guide"

Appendix 3: Learning Activity 2 "Learning Activities for Scene 1"

Appendix 4: Learning Activity 3 "Learning Activities for Scene 2"

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[i] Transfer is the process that occurs when "learning in one context enhances or undermines a related performance in another context" (Perkins and Salomon 1992). The purpose of building transfer into learning is to promote students' ability to recall earlier information, understand how the new material being learned relates to earlier information and to the larger concept, and to apply that understanding in future situations (Donovan, Bransford, and Pellegrino 2000).

In seeking to promote the transfer of learning, it is essential to note that not all learning is equally transferable in all situations. Educators separate transfer into far and near categories, with the near occurring in those situations where both contexts possess numerous identical elements and components. For example, an instructor teaches a student how to solve a math equation in the classroom and then the next day teaches that student how to solve a similar, but more difficult math equation in the same classroom, using the same method. This example demonstrates an extremely close form of near transfer as the two contexts are only minimally different. Far transfer is more difficult to achieve and requires a more in depth understanding as it occurs in situations where the two contexts are vastly different. Taking learning from the classroom out into the real world exemplifies far transfer as almost every element of the context is different and so a deep understanding of the material and its underlying principles is required in order to solve problems or handle scenarios in the different context. Because enhancing learning through transfer is easier in similar contexts (near transfer), it is more effective to train students in an environment similar to the one in which they will be performing the tasks in real life.

[ii] The term screenshots in this case refers to photographs taken by an avatar's camera of objects or scenes in Second Life. In the case of Medulla, screenshots are used to aid the user in matching the description with the specific object or objects described.

[iii] This enhanced knowledge acquisition and retention capability is explained through the theory of low road and high road transfer. Low road transfer is reflexive and triggered by "well-practiced routines by stimulus conditions similar to those in the learning context" and high road transfer is mindful and triggered by "deliberate effortful abstraction and a search for connections" (Perkins and Salomon). Low road transfer, the easier of the two to facilitate, is achieved by maintaining a standard virtual environment. For further discussion of this concept, see: Perkins and Salomon.

Appendix 1. About Medulla

Why Medulla?
Background
Virtual worlds have been around for a number of years in the form of online 3D gaming environments. These virtual worlds have attracted a large number of users worldwide seeking entertainment and socialization on the Internet. But over the past few years, with rapid advances in communication technologies and the emergence of the trend "Web 2.0", the entertainment-oriented, application-only characteristics of virtual worlds have taken a backseat. Like Web 2.0 applications, most virtual worlds offer a variety of built-in tools that allow users to collaborate and create content, including features that enable users to quickly and easily assemble and modify persistent synthetic environments. These persistent virtual world environments are available on-demand and free of charge on the Internet, existing side-by-side with the web and web-based applications. As a result, virtual worlds have rapidly evolved as platforms for content creation with collective intelligence.

Because of this capability the education, research and training communities see virtual world platforms as one of the next generation training and learning tools. Scholars, academics, and technologists around the world can review and share material, content, and best practices to create engaging and informative virtual world experiences and simulations. Once the virtual environment has been created, students, teachers, trainers, professionals, researchers, and all other interested parties can use this same virtual environment for learning, researching and training. The only tools needed are a computer and an internet connection. As a result of this capability, education and research communities have high expectations for the future of virtual world platforms as a training, learning, and collaboration tool. However, at present the utility of these platforms is limited due to several problems with the technology and the virtual world market.

Problem
1. **Crowded VW market:** Many virtual world (VW) platforms exist in the current market. However, not a single virtual world platform has been or is capable to be identified as an ideal platform for users across market segments. Each VW platform differs from the others in areas such as business model, targeted audience, mechanics, rendering capacity, embedded physics, graphics, content delivery, security, intellectual property management, accessibility in enterprise environment and public domain. Users accordingly have preferences for VW platforms based on their requirements.
2. **Cross-VW interaction and content interoperability:** Virtual world technologies are still emerging technologies. Each virtual world has a unique way of storing, delivering and rendering native content, which is often not compatible with other virtual worlds. No standards or protocols have yet been established to exchange VW content objects and source digital assets between two virtual world platforms. Further, users in one virtual world platform are not allowed to communicate and share contents with users in other virtual worlds. There is a high possibility of platform lock-in if a user overly relies on one specific virtual world platform.

3. **Searching VW content on the Web:** At present, no solution is available to search contextualized VW content objects across virtual world platforms. This is similar to the web before the emergence of search engines such as Google, Yahoo and Altavista.
4. **Public media infrastructure:** Groups in academic institutions and small research firms undertake projects. However, once finished, as time passes these projects turn into dead, unmaintained projects for two reasons. First, absence of a distribution or publishing framework to share the project work/outcome with others; Second, a public IT infrastructure to preserve the project work for future use by others.
5. **Authoring synthetic environment for learning:** Many Educators lack the capacity to assemble and manage the resources required to quickly create a compelling synthetic learning environment (such as simulation, game, etc.) or repurpose existing synthetic learning environments for their needs.
6. **Pulling student records for assessment:** A provision is required to connect student records to VW based synthetic learning environments. Educators have access to student records in their parent institutions. In addition, educators are allowed to access SCORM conformant CBT (Computer Based Training) material and assessment modules from their institution's learning management systems.
7. **Scattered web resources:** Web resources are scattered throughout the web, across multiple applications and locked inside user accounts with respective web applications. Powered by Web 2,0 technologies, a multitude of commercial web applications offer functionalities such as data storage, social/business networking and knowledge bases. These applications support safe and seamless online data exchange. These capabilities are accessible online as services on the web. In addition, over the past few years, some of these applications have turned into the well-established repositories of a wide variety of resources –ranging from human resources to digital assets.
8. **Accessing trusted information resources**: Secure and trusted ways need to be explored and implemented to access the trusted information resources that are owned by academic, research and govt. institutions. These institutions possess the IT infrastructure needed for information management and information dissemination. But only institutional members and affiliated members are permitted to use the infrastructure and access these repositories.

About Medulla

Medulla is an intuitive web environment that offers an open-source collaborative toolset to create, manage and use virtual worlds (such as Second Life, Google Earth) for learning and research. Medulla has three broad objectives: facilitate the creation of vetted virtual world-based content; promote the use of the content for learning and research; and ensure the preservation of the content and record activities for future use.

This web environment is platform-independent and accessible side-by-side in any virtual world platform such as Second Life, Open Cobalt, Google Earth, and Active World. A trainer or a researcher who wishes to develop a virtual world environment for training or research purposes creates an online workspace in Medulla and describes the visual and contextual attributes of the virtual world environment, and specify how the virtual world environment needs to be used for training or research. The workspace provides features to build a portal to access digital resources such as materials, work opportunities, lessons,

tools, assessment tests that are needed to be shared or consumed for learning and research using the virtual world environment. Information available on the portal is searchable and viewable by online through search engines like Google, Yahoo and Bing.

Medulla provides a diverse set of open source web tools (online data centers and web applications) that preserve digital resources, and also allows content authors to collaborate with others to create and use virtual world environments and associated resources for learning and research. These tools are hosted as services, maintained in a distributed IT infrastructure and delivered on-demand to authorized medulla users. A web-based authentication and authorization infrastructure ensures trusted access to these tools and other associated digital resources. This infrastructure enables multi-disciplinary user communities worldwide to collaborate in hierarchical or open, collaborative work environments. Also, this approach of provisioning the IT infrastructure as a service, also known as Cloud Computing, relieves end-users from needing to establish the required IT infrastructure and keeping up with constantly changing updates to technologies.

The next phase will enable users of social networking applications such as Facebook, LinkedIn or MySpace to use the Medulla workspaces to access the virtual world environments for learning and research. This approach will facilitate locating and attracting a large and active community of designers and developers from across different disciplines.

Another important planned feature is to offer a safe and secure provision to connect virtual world based learning environments to student records, knowledge bases, lesson plans and assessment tests in domestic learning management systems. FAS also aims to launch a new public media initiative to host, maintain, extend and support these tools in a distributed IT infrastructure management environment with community participation.

Medulla's features lower the barrier to content creation and content reuse for projects that use virtual worlds for learning and research. FAS believes Medulla offers a promising solution for researchers and educators who lack the capacity to quickly create a compelling synthetic learning environment (such as a simulation, game, etc.) or the ability to repurpose an existing synthetic learning environment to meet a new need.

Appendix 2. Second Life Instruction and Practice Guide

Part 1: Overview

Second Life is an open source online virtual environment where almost 100% of the content has been created by the user. Recently, businesses have begun to use Second Life, as a forum to advertise, to have meetings and conferences, to socialize, and to share information. This project represents the next stage of Second Life; utilizing this virtual world as an educational and training tool that is interactive, connected to useful information and activities, and not geographically bound. In this activity you will explore the capabilities of the Second Life virtual world, learning how to: create an account, navigate within the virtual world, connect to the Medulla learning platform, and find supporting materials and data about the objects you encounter in Second Life.

Part 2: Basic Set-up

To install Second Life and create your own avatar (Second Life character), go to www.secondlife.com and click JOIN NOW. Enter a First Name, choose from the list of Last Names and fill out all the other required boxes. You will be sent an email confirming your account creation, and then be prompted to download the software. Download, Install, and Run. Once open, enter your character's first and last name, your password, and click "Log In". You will appear on an orientation island. You can complete the following orientation activity either on the training island or in the orientation area of the FAS Building Inspector SIP Training Island. You can access the FAS area in either of the following ways.

1. Click on the Second Life URL (SLURL) titled "Introduction and Orientation Area" on the Medulla [Building Inspector SIP Training Pilot](#) project page.
2. Click on 'Map' on the bottom toolbar, Search "FAS" and click on the "FAS", then adjust the teleportation coordinates (below the search results box) to 137, 17, 27 and click "Teleport".

Face toward the "SIP Instructional Island" Billboard to begin the activity. If you do not arrive precisely in the orientation area, follow the red arrow that will appear on the screen and it will lead you to the starting area.

Part 3: Basic Movements

Once in the introduction/orientation area you will practice your basic walking techniques. Use the arrow keys (or WASD) for directional movement (forward/back and turning). Walk forwards for about 15 feet, stop, turn 90 degrees to the right and walk forward 5 meters (Second Life is a Metric-based world). Then back up 5m and walk in a tight circle (done by holding Forward or Back while holding Left or Right).
Once you are comfortable with basic movement, press Page-Up or E in order to jump. If you are still on the introduction island, use this technique to jump off the platform you're standing on; otherwise, find something to practice jumping over. In a similar fashion, press Page-Down or C in order to crouch. While in the air, you can actually change your direction of travel, so practice jumping over objects from a stand-still and turning (Page-Up or E, plus Right or Left).
Small steps and low-lying objects can be walked over, while larger objects may require jumping.
After jumping and crouching have been mastered, try flying. Flying can be toggled by pressing Home plus F, or clicking the "Fly" button on the bottom toolbar. Once flying, movement is still controlled by the arrow keys/WASD, but Jump and Crouch are replaced by Fly Up and Fly Down (raising/lowering hover height). To practice: toggle Flying, raise yourself off the ground about 10m and fly forward about 10m. While flying forward, practice raising and lowering your height. Then, fly in a forwards-right circle for a lap or two, stop, and do the same for a forwards-left, a backwards-left and a backwards-right circle. Once you are comfortable with forward and backward movement, turning and adjusting your height practice these movements again, but making very fine, short, accurate movements of less than 1m. In many cases inside the house, one tap of the arrow keys or WASD to change direction or altitude will be all you need to properly position yourself for optimal viewing of a detail within the house.

Part 4: Camera Work
Basic camera movement will be based upon the location of your avatar, as under normal circumstances, the camera will be centered and locked on your avatar, and will follow your movements. Zoom is controlled via the mouse wheel or ctrl-8, ctrl-9, and ctrl-0 (Zoom Out, Reset Zoom, and Zoom In respectively). Sometimes, however, you may find it preferable to separate the camera from the character for closer inspections. This is a rather poorly designed system, but is still very helpful. In the upper right of the screen there should be two boxes: one for camera movement, one for avatar movement (if they're not there, go to View>Camera Controls and Movement Controls). In the camera movement box, the left pad controls the angle of the camera, the middle controls zoom, and the right pad controls movement (up/down, left/right). Keep in mind that if the camera is facing down, 'down' will actually move the camera BACKWARDS. Subsequently moving the avatar will re-lock the camera.

To practice, move your avatar about 10m away from the platform at the entrance to the introduction and orientation area, face the platform and stop. Raise the camera angle (using the left pad in the camera movement box) until looking down at your avatar from above. Then, using the right pad, move the camera's location until directly over top the object of interest. You may want to zoom out to get a wider angle. Once looking directly down at the object, lower the camera angle until horizontal. If the top of the platform is above or below the current camera view, press up or down on the movement pad until correctly adjusted. Spin around the object, zoom in and out, raise and lower the angle and the camera until you've gotten used to moving it all around and examining objects from all sides. Make sure to avoid moving your avatar during this time, as that will re-lock the camera.

Part 5: Mouselook
Another important tool is Mouse-Look. Zoom in all the way with your mouse-wheel, or press M. This will change to a first-person view where the camera is controlled by the mouse. Left and Right now control circle strafing (circling around an object while facing it) rather than turning, and while flying, Forward and Back can adjust both horizontal and vertical movement (relative to how you are facing, as was done with the Camera Movement pad).

Part 6: Touching
Clicking ('Touching' is the SL term) on objects in Second Life can affect the object in many ways. Clicking on objects in our island can: advance to a new slide or go back to a previous slide in a presentation, open up menus of options, link you to the Medulla web page that corresponds to the object and activate or stop object animations. Diagrams, Numbers and Billboards are all clickable/touchable.

If you are still on the orientation island at this point, go to our SIP Instructional Island. Do so in one of two ways:
3.   Click on the Second Life URL (SLURL) titled "Introduction and Orientation Area" on the Medulla Building Inspector SIP Training Pilot project page.
4.   Click on 'Map' on the bottom toolbar, Search "FAS" and click on the "FAS", then adjust the teleportation coordinates (below the search results box) to 137, 17, 27 and click "Teleport".
Read and begin following the instructions on the billboard.

Open the next activity guide, titled "Scene 1 Learning Activities," which is found on Medulla on the Orientation to Second Life and Structural Insulated Panels page. (To find this page, go to the Building Inspector SIP Training Pilot" main page, click on "Scene List" tab toward the top of the page, then click on the "Orientation to Second Life and Structural Insulated Panels" scene.

Appendix 3. Scene 1 Learning Activities:

Introduction

Purpose and Objectives: To familiarize yourself with Second Life and Medulla, especially how to move/operate in Second Life and how to take advantage of the learning materials and activities in Medulla. To acquire a basic level of knowledge about structural insulated panels (SIPs), especially what they are made of, how they are fitted together and how they can be used in construction.

The Activity Guide

Part 1, Orientation: In Medulla, read the 1-page document titled "Second Life Instruction and Practice Guide" (found [here](#)) and complete all of the movement/operating exercises. Before you begin this activity you MUST be familiar with the Second Life terminology and movement explained in the "Second Life Instruction and Practice Guide". When you have completed the activity, read the white bulletin board titled "SIP Instructional Island".

Look just to the left of the white bulletin board at the SIP Instruction and Training Island Orientation presentation. Read through the presentation by clicking on the presentation to advance the slide. This bulletin board/slideshow contains basic information about SIPs, an overview of the Training Island, its scenes and purpose, and finally a link to the Medulla page with in-depth related materials. Look at the slideshow and read through the corresponding orientation materials in Medulla. When you are finished reading the orientation materials, begin the virtual learning aspect of this instruction and training module.

Part 2, The SIP Models: Walk forward into the area with the large 3-D SIP models. Each of the three primary facing materials has its own model. The cementitious SIP is labeled to show all of the component materials of a SIP, including facing, adhesive, and core. Almost all SIP panels possess the same basic components, though the OSB-faced and metal-faced SIP do not have detailed labels. Note that metallic SIPs are thinner than OSB or cementitious.

The next model in this scene is an animation of how two SIPs go together at along a flat wall. Note how the spline and the two panels fit together leaving no gaps in the thermal envelope; once both panels are in place, the spline should not be seen from either side (by flying above the model you should be able to see the top of the spline). Once you have finished looking at the animated models, you should be able to complete Assessment Activity 1: "SIP Components and Materials". When you have correctly answered all of the questions in the assessment activity, move toward the small rotating house diagram next to the Training House billboard. This model house is a completed miniature of the Training House; briefly look over the house to familiarize yourself with the Training House's layout. Read the Training House billboard and follow its instructions, including opening the Training House scene in Medulla.

Appendix 4. Scene 2 Training/Learning Activities:

Introduction

Purpose: The purpose of this scene is to give you a clear picture of what proper SIP building techniques look like and what to look for when inspecting a SIP house. You can go through this virtual practice house as many times as necessary to fully understand the different types of joints, foundation and floor connections, how doors and windows are fitted in a panel, etc. As all architectural and structural details in the house are linked to in-depth explanations, models and drawings you should be able to use the information contained in this scene to practice both for the written assessment and for performing an in-field inspection.

Objectives and Necessary Information: The virtual training house is built to demonstrate a SIP house at multiple stages of construction. While walking through the house, following the activity guide, take special note of any numbered objects/details. These objects are either architectural or structural features unique to SIP construction or represent aspects of SIP building where code compliance issues are frequently seen. Each numbered object has a corresponding photo in the details gallery outside the house. By clicking on each photo, you can obtain detailed information about the object/detail as well as additional photos and drawings of the object. Where the object/detail is particularly intricate, there may be a large-scale model of the object sitting in front of the gallery photo so that you can better see what the object/detail should look when properly installed and code-compliant.

Color Guide to Materials: Within the house different colors represent different materials. This has been done for the sake of visibility, allowing you to easily identify different materials. The information on this chart is replicated on a sign just to the left of the Training Area entrance.

Blue	Splines and Nails (Joining Materials)
Light Blue	Bolts
Red	Flashing
Beige	Foam Sealant
Brown/Green	Wood Framing
Silver-Grey with dots	Metal Framing
Textured Grey	Concrete Walls and SIP exteriors
Textured White on Exterior	House Wrap
Textured White on Interior	Drywall

The Activity Guide

Part 1, Overview of Training House: Begin by reading the billboard outside the Training House, where you will find information on this training house and links to the Medulla site. On the Medulla site you will find the architectural and structural drawings of the training house, videos on how to build and inspect a house constructed with SIPs, diagrams of SIP building details illustrated inside the house and detailed information on SIP building codes, including Section R613 of the 2009 International Residential Code.

As you walk up to the house note the numbered objects. Remember that by clicking on the number above a specific object/detail you can link to either the Medulla website, where you can to learn more about that object/detail, or you can link to the corresponding photo/screenshot in the details gallery to be automatically transported there.

First, fly up above the house, paying special attention to the architectural drawing that forms the floor plan of the house. This drawing is identical to the First Floor Plan (A1.1) in Medulla; at this point if you have not already opened the architectural drawings, you may want to do open them so as to be able to follow along with the plans as you walk through the house. Land at the front of the house facing the front door.

Part 2, The Demo House:

Step 1: SIP joints, corner structural supports, foundation connections

Turn right and walk into the garage (Room 1), located to the right of the front door. The garage has framing, a foundation, 2 corner support columns, and detailed views of how SIPs connect to one another and the foundation. Note that between the garage and main house SIPs, rather than an un-insulated interior wall, should be used.

Begin your exploration of this room by looking first at the foundation details *(detail 1),* especially noting how the SIPs attach to the foundation. After viewing the foundation, you should look at the structural steel columns at the corner (*detail 2*); note how the columns attach to the foundation and to the SIP panel using L brackets, concrete anchors and a thru bolt so that the SIPs are firmly attached both to the column and the foundation.

Next, look at the ½ height SIP wall along the backside of the garage. This wall shows the 4 main types of SIP-to-SIP joints, from right to left (*detail 3*):
1. Surface Spline
2. Block Spline
3. Dimensional Lumber Spline
4. Single Dimensional Lumber Spline

Leave the garage the way you came in stand just outside the front door. As you look at the front door, take note of its placement. Doors and windows should always be placed fully in one SIP panel, never cutout from 2+ sip panels as they will be harder to seal, effectively reducing the R-value of the wall.

2: Interior Framing
Walk in the front door (*detail 4*). You will notice that the interior structural framing of the house is done in steel, while the framing and studs around doors and windows is in wood 2x4s. Steel framing is not a necessity is a SIP house, but is recommended for the climate and weather conditions of Houston, Texas where this house was built.

3: Corner joints
Just inside the front door turn left to the Living Room (Room 2). The corner joints are presented in a series showing the different stages of construction, beginning at the corner to your immediate left (the corner between the living room and the wall with the front door) and continuing clockwise around the room. (*interior=detail 5*)(*exterior=detail 6*)

- Interior Corner 1: Corner connection with screws, but no caulking/sealant, trim or cladding
- Exterior Corner 1: Corner connection with screws, but no caulking/sealant, trim or cladding
- Exterior Corner 2: Corner connection with screws and caulking/sealant, but no trim or cladding
- Exterior Corner 3: Corner connection with screws, caulking/sealant and cladding, but only half of the exterior trim
- Interior Corner 2: Corner Connection with screws and caulking/sealant, but no cladding or trim

Walk along the outer wall of the Family Room (Room 3) with the wall to your left past two windows and a door. Stop at the corner where the family room meets the Leisure, Office or Bedroom (Room 4).

- Interior Corner 3: Corner connection with screws, caulking/sealant, trim and exterior cladding

Now take a right and walk into the Leisure, Office or Bedroom (Room 4) and walk to the corner, which is the final, completed exterior corner.

- Exterior Corner 4: Corner connection with screws, caulking/sealant, trim and cladding

4: Windows and doors

After you have looked at all of the corners and have a good understanding of how the different types of SIP corners look, exit the Leisure, Office or Bedroom (Room 4) and walk across the Family Room (Room 3) and the Dining Room (Room 5) and out the side door in the Dining Room. Once outside, turn around to the right so that you are facing the exterior of the house (the top wall in the drawings). From left to right, the 5 windows in front of you illustrate the steps in installing a non-load bearing window in a SIP panel with housewrap (*detail 7*). The steps are to: cut an I-shape in housewrap, fold the housewrap away from opening and secure tightly, install the sill pan in two pieces (attaching to exterior face only), tape or flash the sill pan at jambs and sill joint and install the window as per the manufacturer's specifications.

Walk back toward the door in the Dining Room (Room 5) you exited the house from. Load bearing windows and doors, such as this door, have very specific requirements to ensure their thermal efficiency, including an insulated header and recessed studs on either side. The window in the gable on the back wall of the house is also a load bearing window. You should fly up to the window (*detail 7*) to see how weight is distributed on the header and it will be particularly useful in this case to open up the framing drawings in Medulla.

5: Roof Ridge and Roof Panel Joints

Walk back into the middle of the Family Room (Room 3) and face toward the back of the house with the bedrooms. Look up toward the roof ridge (using the Mouselook setting is essential for this step). There are two sections of roof, each of which features one different type of roof ridge and two different methods to connect and seal roof panels. The closest roof panel (directly above the Family Room) features:

- one roof ridge with internal framing (*detail 8*)
- one roof panel connection with a wood "I joist" (right) (*detail 10*)
- one roof panel connection with a single wood framing board (left) (*detail 10*)

Fly up to this roof section and look at all three details up-close. When you feel comfortable with your understanding of how the panels are fitted together, fly to the second roof section (which is connected to the rest of the roof). This roof section features:

- one roof ridge without internal framing (*detail 9*)
- one roof panel connection with a spline (right) (*detail 10*)

- one roof panel connection with a double wood framing board (left) (*detail 10*)

When you have looked at the second roof section and can positively identify the nails, bolts, sealant and framing/splines in each connection, land in the Family Room (Room 3), again facing the bedrooms.

Now look at steel framing of roof and the walls. While steel framing is not necessary in all houses, this training house is modeled on a house built in Houston, Texas, and best practices for this area require steel roof and structural framing in order to mitigate hurricane damage.

6. Beveled Wall-Roof Joints

Walk to the right of the bar, down the hallway and take a right. Once in Bedroom Suite (Room 6), walk to the left (into the bedroom labeled Bedroom 3 on the architectural drawings) and face the window. Looking slightly up to where the wall joins the ceiling you will see two detailed roof panels connected to the wall with a space in between. These two roof-wall connections are beveled connections, with the right panel showing beveled blocking and the left a beveled SIP wall (*detail 11*). The key to note in both cases is that the roof panel should never be cut into as this will decrease the R-value of the roof, causing extensive thermal losses along the connection. You will need to fly up to the connection in order to see the interior details. Once you have looked at both connections and can identify the differences and similarities between them, land back in the Bedroom Suite (Room 6).

7. Ceiling Fixtures

Standing on the floor of the Bedroom Suite (Room 6) look up at the ceiling. On the ceiling you will see two fixtures—one white lamp and one wired blocking (*detail 12*). As you can see, the wires for both are located in the chases (pre-cut channels) that run through the roof panel and the air cavity around the fixture is filled with an expanding foam. For all exterior and roof electrical wiring it is essential that the wires be located within the manufactured chases and not be cut by electricians on-site.

8. Electrical Wiring

Turning around and looking at the back wall of the Bedroom Suite (Room 6) you will notice an outlet in a baseboard, 2 horizontal chases in the wall, 1 outlet adjacent to each chase, and vertical wiring running through the interior wall to the left (*details 14 and 15*). Where possible, electrical wiring should be run through interior walls, under the floor or behind a baseboard. Where not possible, SIPs have both horizontal and vertical chases cut into them that allow electrical wires to be run through the SIP without an electrician cutting into the SIP itself. Pay special attention to the manufacturer's plans regarding the location of chases and ensure that the electricians are utilizing the chases, where applicable, rather than cutting new routes for wiring and that all outlets are located adjacent to the chases and properly sealed. When you have followed the wires from the chases to the internal walls and looked at the outlet in the baseboard, leave the Bedroom Suite (Room 6) and walk straight ahead to the Master Bedroom (Room 7).

9. Hanging Floor and Rim Board Connections (Second Story Connections)

Once in the Master Bedroom (Room 7) turn right and look at the two adjacent closets on the far side of the room. Above the closets are cutout sections of a hanging floor (to the right) and a rim board (to the left) connection in order to simulate proper attachment of a second-story to the external SIP walls (*detail 13*). Look at both models up-close, paying special attention to the differences between the two.

For both of these models it is important to look at the corresponding detailed pictures in Medulla as there are lots of small details in how the floor connects to the SIP wall. Note that especially in the case of the rim board (left) the gap between lower and upper SIP must be filled with a foam sealant.

10. Plumbing
Walk from the Master Bedroom into the Master Bath (Room 8) and turn to the left.   The plumbing for this bathroom is located on the left interior wall (*detail 16*). Plumbing should always be located on an interior rather than exterior wall, where possible, but this is extremely important when using SIPs as plumbing within an exterior wall will require cutting into the SIP in the field (unlike with electricity, there are no manufactured chases for plumbing built into the SIP). Plumbing in a SIP house is otherwise identical to plumbing in a non-SIP house.

You have now looked at all of the objects/details within the Training House. If you have not done so already exit the house via the Family Room Door and go out to the Screenshot Gallery.

Part 3, The Gallery: Here in the Gallery you will find screenshot images of all the details you have seen in the house, links back to the object/detail within the house, links to more information about the object/detail back in Medulla and in some cases larger-scale models of the object/detail.

You will also find 3 models located at the far end of the gallery of objects/details that are not part of the Training House. These 3 models of a roof valley (*detail 17*), cantilever floors (*detail 18*), and overhanging floor (*detail 19*) are not included as the architectural drawings for this house do not include these features. However, SIP construction with regards to these features is sufficiently unique from standard stick built construction that it is useful for you to look at the models, especially noting how they are insulated and how the SIP connections are made with minimal penetration of the SIP core.

Numbering of Details in House and in Gallery:
1- *Foundation*
2- *Corner Support*
3- *SIP Wall Connections*
4- *Door Frame*
5- *Interior Corner*
6- *Exterior Corner*
7- *Windows*
8- *Roof Ridge With Cap*
9- *Roof Ridge Flush*
10- *SIP Roof Connections*
11- *Roof-Wall Connections*
12- *Ceiling Fixtures*
13- *Rim Board/Hanging Floor*
14- *Electrical*
15- *Baseboard Electrical*
16- *Plumbing*
17- *Roof Valley*
18- *Cantilevered Floor*
19- *Overhanging Floor*